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AN ACCIDENT IN HISTORY: *CHALLENGER* IN PERSPECTIVE

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Figure 1: Walking *Enterprise* to Dynamic Test Stand--1978

Introduction

For several years since the publication of a history of Marshall Space Flight Center, I have been studying the origins and meaning of the Space Shuttle *Challenger* accident.[1] My long-term goal is to write a book on the history of the accident, and the 2002 NASA Faculty Fellowship allowed me to make substantial progress toward that goal. This summer I wrote about half the manuscript chapters, filled in numerous gaps in my research, interviewed several Marshall officials, and scanned dozens of photographs and engineering illustrations.

My book will differ in several respects from previous studies. It will cover a longer span of time and events—most books begin with the test phase of the solid rocket motor and end shortly after the accident. Mine will go back to the Apollo Program and discuss the testing and quality control methods used on the Saturn rockets. It will also include considerable coverage of the origins of the shuttle configuration and program management system. In addition, it will also go forward beyond the accident, with almost half the book discussing the post-accident investigations, the redesign of the shuttle and boosters, and the interpretations about the tragedy that appeared in scholarly publications. Its focus will be comprehensive, but will concentrate on the history of solid rocket motor engineering and technology. Most previous studies have made engineering secondary to an examination of communications or bureaucracy.

A Primer on Interpretations of the Accident

The stories about *Challenger* all agree (well, virtually all agree, but that is another story!) that the accident occurred because of a failure in the joint of the steel case of one its solid rocket motors. Beyond this basic fact, interpretations disagree.

Figure 2: Transport of Structural Test Article-1--1977

The orthodox interpretation of the accident is that engineers who worked on the solid rocket motor had understood the technical hazard before the fatal flight on 28 January 1986, but that their managers had failed to communicate that hazard to shuttle program managers and thus had failed to stop shuttle flights and fix the joint problems. This view claims that engineers had understood the dangers and recognized the limitations of the field joints in the motors, and that managers had failed to pass along this information. In other words, the dominant view is that the engineers knew the hazard and that their managers did not tell; consequently they failed to prevent an accident.

This interpretation was central in the report of the Presidential Commission that investigated the accident.[3] With this report as a starting point, most academic studies have emphasized managerial, communications, and moral failures as the primary causes of the *Challenger* disaster. Often such studies have relied, implicitly or explicitly, on considerable "counter-factual" logic, contending that "if only" historical actors had communicated better, then events would have unfolded differently and the accident would not have happened. If only the managers had listened, if only the managers had reported, if only the managers had not felt pressure to launch, and so on.

At least one explanation departed from this pattern. Most notably, Diane Vaughan, a sociologist, argued that the orthodox interpretation had been shaped by a search for blame after the accident, and so had focused on managerial malfeasance. In a thorough and thoughtful interpretation of the disaster, she turned the bad management thesis on its head, and contended that managers had followed NASA rules and communicated engineering information properly. Rather than rule violations, Vaughan maintained that the accident happened because the engineers and managers followed NASA rules and norms. The structure of the space economy spawned formal rules and cultural patterns that led to engineering "mistakes" that were "socially organized and systematically produced." Accepting imperfect designs was normal for rocket engineers who worked in an organizational environment characterized by limited budgets, tight schedules, and efficiency procedures. Accordingly Vaughan found no malfeasance, but believed that Congress and the White House had created a "bureaupathological" structure in which marginal technology and undue risk-taking was normal. She contended that the accident proved "the inevitability of mistake" in any bureaucracy working with "risky technology."[4]

<u>A Technological History</u>

My approach finds flaws in both types of interpretations and seeks a balance between the extremes that is consistent with all the evidence. The managerial interpretation misinterpreted the engineers' understanding of the joints prior to the accident. The engineers, rather than classifying the joints as hazardous, considered the joints to be safe and reliable. Their managers' reports to shuttle program officials, rather than hiding a hazard, correctly communicated their engineers' consensus that the joints were safe. In other words, the engineers did not know that the joint problems were hazardous, and their managers did tell of the safety and reliability of the joints.

Vaughan also made mistakes. By arguing that there was no wrongdoing and no norms were violated, in effect she made the absurd claim that NASA had no norms for ensuring the safety of launch vehicles and people on them. Her ideas were fatalistic because she called the solid rocket motor "risky technology" that could "never be known" or realistically tested.[4] Accordingly Vaughan, like other interpreters, focused on engineering communications rather than looking at engineering methodology. She mistakenly assumed that bureaucracy made the accident inevitable, and ignored the evidence of successful engineering in bureaucracies, including in the space shuttle program. Engineers working on the space shuttle main engine before the accident, for example, operated in the same social environment as those working on the solid rocket motor, but the SSME technology did not fail. Moreover after the accident, engineers redesigned the solid rocket motor and it too has operated successfully and safely.

Figure 3: Development Motor 2--1978

Like previous studies, my interpretation recognizes that rules were violated and norms were followed, but emphasizes neither. Rather my approach seeks to understand how the engineers studied the motors and what conclusions they drew. Rather than evidence pointing to malfeasance or "bureaupathology," most of the evidence shows engineers using the state-of-experience methods that seemed to verify the safety of the joints. When they encountered problems with the motor's field joints, they carefully reanalyzed the data, and conducted more tests. But unwittingly, they performed work with flaws that prevented realistic understanding of the limitations of the technology and the risks. Accordingly they believed that the data and tests showed that the joints were safe. Only after the tragedy did the engineers realize that their previous methods had not been rigorous or realistic enough.

After the accident, they had new data that gave them clues about the limitations of their designs. Consequently they recognized the previous mistakes, developed new tests and procedures, and successfully created a new robust design.

Such a technological approach puts engineering at the center, emphasizing design principles, test procedures, and assessment processes. My goal is to write a history that will serve people outside and inside aerospace. A study that focuses on technology will help outsiders see engineering in practice, and explore the social and political context in which engineers work on the daily activities of design, development, testing, analysis, and review. A history of the shuttle's solid rocket motor project will be useful for insiders, especially in describing how engineers inadvertently made mistakes, but quickly learned from them.

Indeed a primary goal of my history will be to ensure that what the engineers experienced and learned is not forgotten. Their lessons remain the greatest memorial to the astronauts who died aboard *Challenger*, the greatest testament to their professionalism as engineers, and the most important legacy of the accident. A year before the accident, Henri Petroski, an engineer, humanist, and author of *To Engineer is Human*, reflected on the role of failure in engineering design, and explained that

> colossal disasters that do occur are ultimately failures of design, but the lessons learned from those disasters can do more to advance engineering knowledge than all the successful machines and structures in the world. Indeed, failures appear to be inevitable in the wake of prolonged success, which encourages lower margins of safety. Failures in turn lead to greater safety margins and, hence, new periods of success. To understand what engineering is and what engineers do is to understand how failures can happen and how they contribute more than successes to advance technology.[2]

By relating the *Challenger* story of failure and learning, I hope to contribute in some modest way to readers' understanding of engineering and space exploration.

Resources

In conducting my research and writing during the fellowship, I mainly worked from the Marshall Space Flight Center's History Archives. The archive has various historical records, including files from past Center Directors, technical reports, photos, videotapes, and news articles. The collection is outstanding and has a marvelous digital finding aid. I also conducted several oral history interviews.

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